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Original Article

Influence of Traditional Smoking Methods on Quality and Safety of Farmed Mullet Fish (*Mugil cephalus*) in Fayoum governorate, Egypt

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ABSTRACT

This study was carried out to determine the effect of traditional smoking methods on physiochemical quality and potential risks by biogenic amines and microbiological aspects of mullet fish (*Mugil cephalus)* obtained from two farms (1 and 2); irrigated El-Batts and El-Wadi drains, respectively, located in Fayoum Governorate. The results revealed that values of quality parameters and biogenic amines in raw and smoked mullet from farm (1) were higher than from farm (2). Values of quality parameters and biogenic amines of hot smoked lower than cold smoked fish. Histamine and tyramine levels decreased by smoking, but spermine, putrescine and cadaverine increased. Total bacterial count (TBC) of raw fish from farm (1) was 4.26 Log_{10}cfu/g decreased to 3.35 and 3.05 log_{10}cfu/g of cold and hot smoked samples, respectively. On other side TBC of raw sample farm (2) was 3.36 Log_{10}cfu/g decreased to 3.12 and 2.85 Log_{10}cfu/g of cold and hot smoked samples. Yeasts and mold (Y&M) recorded 1.88 Log_{10}cfu/g for raw sample farm (1) decreased to 1.20 and 0.82 Log_{10}cfu/g of cold and hot smoked samples, whereas the recorded 1.54 Log_{10}cfu/g in raw samples from farm (2), decreased to 1.00 and 0.50 log_{10}cfu/g of cold and hot smoked, respectively. Therefore, from obtained results, it could be concluded that cold and hot smoked samples from farm (2) has higher quality and safety than from farm (1). Also, Hot smoked samples were higher quality and safety than cold smoked. So, Cold and hot smoking process could be reduced the values of risk sources and raised the safety level of consumer.

Keywords: Mullet fish, smoking methods, biogenic amine.

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1. INTRODUCTIO

Fish is known to be a source of protein as they are rich in essential amino acids (lysine, methionine, cystine, threonine, and tryptophan) (Sikorski, 1994), micro and

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macro elements (calcium, phosphorus, fluorine, iodine), fats that are valuable sources of energy, fat-soluble vitamins and unsaturated fatty acids. They also have a hypocholesterolemic effect (antiarteriosclerosis) (Fernandez and Venkatrammann, 1993).

Fish is usually processed and cooked in different methods such as salting, smoking, boiling, roasting, frying and grilling. These processing and cooking methods improve the hygienic quality by inactivation of pathogenic microorganisms and enhance the digestibility and bio-availability of nutrient in the digestive tract (Kocatepe *et al.*, 2011).

Smoking is one of the oldest methods used to process and preserve fish (Simko, 2002; Stołyhwo and Sikorski, 2005 and Bilgin *et al*., 2008). Smoking can inhibit the formation of toxins in products (University of Florida, 2004), reduce the growth of bacteria, due to lower water activity by smoking in combination with salting and drying which creates a physical surface barrier (Rørvik, 2000). Moreover the spoilage and pathogenic microflora of smoked products are affected by density of smoke, concentration of active components of the smoke in combination with the salt content, and the time and temperature of smoking (Kolodziejska et al., 2002).

Hot smoking is known as the traditional smoking method (Arason et al., 2014). Traditional smoking is generally performed by the formation of smoke from wood (Duedahl-Olesen et al., 2010 and Visciano et al., 2008). Smoke is defined as the result of thermal pyrolysis of wood when access to oxygen is limited (Purcaro et al., 2013). The smoked products have high salt and low moisture content. Safe hot smoked fish requires at least 3.5% water phase salt (WPS). An internal temperature of smoked product must be achieved at least (62.8 °C) for at least 30 minutes (Kenneth and Hilderbrand, 1992; University of Florida, 2004). This prevents the production of toxins by *Clostridium botulinum* (Kenneth and Hilderbrand, 1992). Additionally, water activity (a_w) of hot smoked fish products must be less than 0.85 to make products stable at room temperature (Arason et al., 2014).

Vacuum packing and chilled storage should be followed by cold smoking because product is not completely preserved (Kenneth and Hilderbrand, 1992 and Rørvik, 2000).

Biogenic amines (BAs) are low molecular weight organic bases with biological activity that are mainly formed in foods by microbial decarboxylation of amino acids and transamination of aldehyde and ketones. Certain biogenic amines such as histamine (HIM), cadaverine (CAD), putrescine (PUT) and tyramine (TYM) are importance, due to the risk of food intoxication and also they serve as chemical indicators of fish spoilage (Kim et al., 2009 and Zhai et al., 2012). BAs are found at low levels in the body tissues of fresh fish, but their formation in larger quantities is associated with the decomposition of fish muscles (Prester, 2011).

Histamine is potentially hazardous and the causative agent of histamine intoxication associated with the consumption of seafood (Morrow et al., 1991). Moreover, histamine levels in freshly caught fish are generally very low, usually below 0.1mg/100g (Auerswald, 2006). Besides histamine, such secondary amines as putrescine and cadaverine are good indices of spoilage of marine fish (Mietz and Karmas, 1977). Therefore, Food and Drug Administration (FDA) has set the maximum action level of histamine as 50 mg /Kg for fish (FDA, 2011) while, a level of 200 mg /Kg of food was ruled by the European Community (EC, 2005) that established in Germany. Also, 100 mg histamine /Kg of food was accepted in

Canada, Finland and Switzerland. In Egypt, Egyptian Standard Specifications (ESS, 2005 for salted, smoked, frozen fish) evident the maximum permissible limit of histamine content must be not exceed 200 mg/kg for salted, smoked and frozen fish products.

Therefore, this work was planned to investigate the effect of traditional smoking methods (cold and hot smoking) on quality criteria, potential risks by biogenic amines and microbiological aspects of smoked mullet fish obtained from two fish farms (1,2) in Fayoum Governorate to determine the quality and safety of smoked mullet products for consumers.

1. MATERIALS AND METHODS

1.1.Materials

***Fish sample*:** Mullet (*Mugil cephalus)* samples were obtained from two fish farms (1 and 2) irrigated from El-Batts and El-Wadi drains, respectively during September, 2020.The averages of weight and length were 305±40g and 33±2 cm for raw samples obtained from farm (1), while, 255±50g and 30.5± 2.5 cm for raw samples obtained from farm (2). Fish samples were immediately transported using ice box from farms to Fish Processing and Technology Lab., Shakshouk Fish Research Station, National Institute of Oceanography and Fisheries (NIOF), Egypt.

Ingredients: Sodium chloride (BONO) produced by Egyptian Salts and Minerals Company (EMISAL) was used. It composed of 98.5% sodium chloride, 30-70 ppm potassium iodate and 0.3% humidity. Sawdust as a smoke source was purchased from carpentry workshop at Fayoum city.

Smoking methods*:* The traditional methods of cold and hot smoking were carried out in smokehouse that prepared by Abd El-Mageed (1994) with some modifications at Shakshouk Fish Research Station, (NIOF). The smokehouse had inside dimensions of 2.20×1.0×3.5m with perforated metal sheets placed 75 cm above the smoke source. Mullet fish samples were washed gently with tap water and immersed in brine solution at a ratio of 1:1 (w/v) containing 10% Nacl for 2 hrs, rinsed with tap water for 1 min to remove the excess salt, drained; semi-dried at 25-28°C in sunny air for 2 hrs and hooked in smokehouse above the smoke source by about 2.5 m for 10-11 hrs. at 35-45°C for cold smoking method, and by about 1.5 m for 5-6 hrs at 40-90°C for hot smoking method using sawdust as smoke source. After smoking the fish samples were cooled under ambient temperature. Both cold and hot smoked mullet fish samples were analyzed immediately after smoking for physiochemical, (biogenic amine and microbial load) and sensory properties.

1.2.Analytical Methods

Analysis was made on raw mullet fish meat samples immediately after the preparation and after smoking.

Physico-Chemical Quality Parameters: The pH value was measured according to the method described by AOAC (2012). Total volatile basic nitrogen (TVB-N) was determined by the Macro distillation method proposed by Pearson (1991). Trimethylamine nitrogen (TMA-N) was determined using the standard method as described by the AOAC (2012). Thiobarbituric acid number (TBA) was determined by Pearson (1991).

***Determination of Biogenic Amines*:** Five biogenic amines included histamine, tyramine, cadaverine, putrescine, spermine were estimated in both raw and smoked fish samples at the National Research Center, Dokki, Cairo, Egypt by using HPLC (High performance

liquid chromatography) according to (Mietz and Karmas, 1977 and Krause *et al.*, 1995). The results were expressed as mg/kg (W.W)

1.3. Microbiological analysis: The samples of raw fish and smoked fish mince were analyzed for microbial profile using standard procedures (APHA, 1992) for total bacterial count (TBC) (30°C for 3 days) on plate count agar, yeast and mold (Y&M) counts on potato dextrose agar (21°C for 5 days). The total coliforms was performed as described by AOAC (2012) using the most probable number (MPN) method. Three tubes of Lauryl Sulphate Tryptose broth were used for each dilution (1:10, $1:10^2$, $1:10^3$, $1:10^4$ and $1:10^5$) and the tubes were incubated at 35 ºC for 48 ±2 h for gas formation. After primary incubation, one loopful of the positive tubes (gas formation tubes) was transferred to Brilliant Green Lactose Bile media for total coliforms (incubated at 35 ºC for 48 h)**.** The results were expressed as $\log_{10}$cfu/g of sample.

1.4. Statistical analysis: the results obtained were statistically analyzed using the standard deviation (Mean ± SD) as reported by (Gomez et al., 1984).

2. RESULTS AND DISCUSSION

3.1. Effect of traditional smoking methods on

3.1.1. Physiochemical quality criteria of farmed mullet fish

pH value

pH value is the only measurement which has been commonly used as physical method for quality assessment of fish meat (Mhongole, 2009). The results in Table (1) showed that the pH value of raw mullet fish obtained from farm (1) was 6.27 decreased to 6.08 and 6.13 of cold and hot smoked samples, respectively. While, pH value of raw mullet fish obtained from farm (2) was 6.10 decreased to 5.92 and 6.02 of cold and hot smoked fish samples, respectively. The decrease of pH values of smoked samples might be attributed to the absorption of some organic acids from the smoke by the flesh during smoking processing. Similar results were reported by Abd El- Mageed (1994) studied the effect of smoking process on the quality attributes of silver carp fillets and observed that pH value of fresh sample decreased from 6.70 to 5.52 and 5.64 in the hot and cold smoked fillets, respectively. Yanar (2007) reported that pH value of fresh catfish flesh (*Clarias gariepinus*) decreased from 6.78 to 6.74 in the smoked catfish. Abo-Taleb et al. *(*2011) reported that pH value of silver carp fillets decreased immediately after smoking process and the decreasing was much higher in cold smoked samples than in hot smoked samples. El-Lahamy et al. (2019) found that pH value of raw catfish fillets was 6.40 while hot and cold catfish fillets showed pH values of 6.10 and 6.20, respectively.

***Total volatile basic nitrogen (TVB-N*)**

The total volatile basic nitrogen (TVB-N) values of raw mullet fish from farms (1 and 2) were investigated Table (1). TVB-N was 15.12 mg N/100g flesh (on wet basis) of raw fish from farm (1) increased to 18.16 and 21.88 mg N/100g of cold and hot smoked samples, respectively. TVB-N value of raw mullet fish obtained from farm (2) was 12.65 mg N/100g increased to 15.16 and 16.30 mg N/100g of cold and hot smoked fish samples, respectively. These TVB-N values of raw and smoked fish samples were much lower than acceptable limit which ranged between 30-40 mg TVN/100g sample (Connell, 1976). The increasing of TVB-N after smoking process most likely caused by an autolytic process which produces volatile amine compounds

during smoking process. The similar results were found by Yanar (2007) found that the total volatile basic nitrogen (TVB-N) of raw catfish *(Clarias gariepinus)* fillets increased from 15.47±0.22 mg/100g to 17.67±0.81mg/100g in hot smoked product. Koral and Tufan (2009) studied the effect of smoking process on the quality criteria of garfish and stated that the total volatile basic nitrogen (TVB-N) of raw fish increased from 9.81±0.12mg/100g to 10.48±0.07mg/100g in hot smoked sample. El-Lahamy (2018) indicated that TVB-N significantly (P<0.05) increased in smoked catfish samples in comparison with fresh unsmoked fish. He found that TVB-N values in fresh, hot and cold smoked samples were 13.77±0.098, 17.80±0.173 and 18.95±0.202mg/100g, respectively. On the contrary of this observation, Abd El-Mageed (1994) observed that total volatile basic nitrogen (TVB-N) content of silver carp fillets decreased from 36.21mg/100g in raw fillet to 30.79 and 21.52 mg/100g (on dry weight basis) in cold and hot smoked fish products, respectively. Also, Ibrahim (1999) observed that after herring smoking , TVB-N value decreased; might be due to the heat used during smoking caused to evaporate some of TVB-N content.

Trimethylamine nitrogen (TMA-N)

TMA-N is used to determine the quality of products and it has been mentioned that fresh fish with less than 1.5 mg TMA-N/100g flesh is considered as a good quality and 10-15mg TMA-N /100g is regarded within the acceptable limits (Connell, 1976). The data of Table (1) evident that TMA-N of raw mullet fish from farm (1) was 0.66 mg/100g sample increased to 0.72 and 0.88 mg/100g of cold and hot smoked fish samples, respectively. Also, TMA-N of raw mullet fish from farm (2) was 0.48 mg/100g sample increased to 0.60 and 0.68 mg/100g of cold and hot smoked fish samples, respectively. This increase of TMA-N during fish smoking may be produced by the decomposition of trimethylamine oxide (TMAO) that due to bacterial spoilage and enzymatic activity (Koral and Tufan, 2009).These results are in agreement with reported by Abo-Zeid (2020) he observed that TMA-N value of fresh catfish fillets was 0.20 mg/100g sample increased significantly (p<0.05) to 0.41 mg/100g of smoked control samples and to 0.35, 0.30 and 0.33 mg/100g of smoked catfish fillets treated by thyme, rosemary and cumin, respectively. On the contrary of this observation, Hegazy (1998) and Ibrahim (1999), they evidenced that TMA-N in fish was decreased by smoking.

Thiobarbituric acid values (TBA)

As shown in Table (1), TBA value of raw mullet fish from farm (1) was 0.52 mg malonaldehyde (MAD)/kg sample increased to 0.68 and 0.80 mg MAD/kg of cold and hot smoked fish samples, respectively. While, its value of raw mullet fish from farm (2) was 0.35 mg MAD/kg sample increased to 0.51 and 0.63 mg MAD/kg of cold and hot smoked fish samples, respectively. However, the thiobarbituric acid values in the smoked samples were less than the levels reported for the rejected samples and were still acceptable. The obtained data of TBA is much lower than the acceptable limit that 2.0 mg MAD /kg (Bonnel, 1994). The increase f TBA values in the smoked fish might be originated from the breakdown of oxidation products, mainly malonaldehyde, during smoking due to the high temperature (Goktepe and Moody, 1998), this explains why the TBA value was increased in hot smoked samples compared to cold smoked samples. Similar results were reported by Bilgin et al., (2008) reported that the tiobarbituric acid (TBA) of raw gilthead sea bream (*Sparus aurata* L., 1758) was 0.59 mg malonaldehyde/kg and this value increased to

1.03and 0.83 mg malonaldehyde/ kg in the hot and cold smoked samples, respectively. Koral and Tufan, (2009) found that the thiobarbituric acid (TBA) value of raw garfish increased from 0.66±0.04 mg malonaldehyde /kg to 0.84±0.04 in the smoked product. El-Lahamy (2018) indicated that the thiobarbituric (TBA) values for raw catfish fillets significantly ($P<0.05$) increased from 0.23±0.017 to 0.44±0.023 and 0.29±0.011 mg malonaldehyde/kg in hot and cold smoked samples, respectively.

Table 1: Effect of smoking methods on quality criteria (w.w.) of mullet fish obtained from farms 1 and 2

Constituent (%)	Farm 1			Farm 2		
	Raw fish	Smoked fish		Raw fish	Smoked fish	
		Cold	Hot		Cold	Hot
pH value	6.27 ± 0.22	6.08 ± 0.33	6.13 ± 0.08	6.10 ± 0.20	5.92 ± 0.11	6.06 ± 0.09
TVB-N(mg\100 g)	15.12 ± 0.38	18.16± 0.03	21.88 ± 0.22	12.65 ± 0.14	15.16 ± 0.08	16.30 ± 0.31
TMA-N(mg\100 g)	0.66 ± 0.03	0.72 ± 0.21	0.88 ± 0.10	0.48 ± 0.07	0.60 ± 0.32	0.68 ± 0.20
TBA (mg MAD\kg)	0.52 ± 0.10	0.68 ± 0.04	0.80 ± 0.08	0.35 ± 0.09	0.51 ± 0.08	0.63 ± 0.11

Data (n=3) are calculated as mean ± (SD) Standard deviation; Farm 1: Irrigated from El-Batts drain, Farm 2: Irrigated from El-Wadi drain, w.w.: On wet weight basis, TVB-N: Total volatile basic nitrogen, TMA-N: Trimethylamine nitrogen, TBA: Thiobarbituric acid

3.2. Biogenic amines of farmed mullet fish

Biogenic amines determination in food has both safety and quality issues. The contents of biogenic amines (spermine, putrescine, cadaverine, histamine, tyramine) in raw and smoked mullet fish are shown in Table (2). The present results illustrated that variations between all investigated samples regarding to biogenic amines contents depended on the size of the fish in the same species, fishing area and smoking method. It could be noticed that, cadaverine, histamine and tyramine are predominant amines in all raw and smoked fish samples and the highest values were recorded (17.45, 16.00 and 10.90 mg/kg) in cadaverine of cold smoked fish from farm (1), histamine and tyramine of raw fish from farm (1), respectively. histamine and tyramine decreased by cold and hot smoking methods; this due to the smoking may be capable of inhibiting or inactivating biogenic amine producing microorganisms, while spermine, putrescine and cadaverine increased. The values of histamine and tyramine of raw fish from farm (1) were 16.00 and 10.90 mg/kg, decreased to 12.07 and 6.72 of cold smoked fish and 6.80 and 4.41 mg/kg of hot smoked fish, respectively. While for raw fish from farm (2), the values of histamine and tyramine were 8.00 and 5.60 mg/kg, decreased to 3.00 and 4.80 of cold smoked fish and 1.23 and 3.45 mg/kg of hot smoked fish, respectively. On the contrary, spermine, putrescine and cadaverine were 2.90, 5.22 and 9.08 mg/kg of raw fish from farm (1) increased to 5.45, 8.90 and 17.45 of cold smoked fish and 3.00, 6.52 and 12.00 mg/kg of hot smoked fish, respectively. Concerning raw fish from farm (2), the values of spermine, putrescine and cadaverine were 0.74, 1.01 and 8.80 mg/kg increased to 2.71, 3.33 and 11.40 of cold smoked sample and 1.50, 1.84 9.12 mg/kg of hot smoked fish, respectively. The biogenic amines values of

raw and smoked samples of mullet fish from (1) were higher than samples of from farm (2).

Also, according to the mentioned results, our data showed that all detected biogenic amines in all the investigated raw and smoked fish samples were much lower than the hazard levels as recommended by some authors (Nader et al., 2016 and El-Sayed, 2014). Also, no samples reached toxic levels of 500 ppm, a value at which one would expect illness and that the FDA would use in legal proceedings (EEC 1991 and FDA 1998).

Also, it could be found that the hot smoked samples of fish obtained from farms (1and 2) were lower of biogenic amines values than cold smoked samples, this may be due to the hot smoking may inhibit histamine producers, cold smoking does not expose the fish to high temperatures enough to inhibit the latter bacteria (Flick et al., 2001) The similar results were found by Bouzgarrou and Sadok (2017); they reported that after cold smoking of freshwater thin-lipped grey mullet (*Liza Ramada*) fillets, the levels of agmatine and histamine significantly decreased with the appearance of cadaverine. On the contrary, Flick et al. (2001) recorded that the value of histamine of fresh mackerel fish was not detected but hot smoked sample contained 42.00 mg/kg. Thawed mackerel fish previously frozen for 11 wk contained 3 mg/kg increased after hot smoking to 44.00 mg/kg, thawed frozen mackerel fish for 22 wk contained 51.00 mg/kg histamine increased to 63.00 mg/kg after hot smoking, thawed mackerel fish previously frozen for 33 wk contains 53 mg/kg increased after hot smoking to 94.00 mg/kg, the authors explained the reasons for. However, microorganism growth and potential toxin formation may occur after thawing and post processing.

Table 2: Effect of smoking process on biogenic amines (w.w.) of mullet fish flesh obtained from farms 1 and 2

Biogenic amines (mg/kg)	Farm 1			Farm 2		
	Raw fish	Smoked fish		Raw fish	Smoked fish	
		Cold	Hot		Cold	Hot
Spermine	2.90	5.45	3.00	0.74	2.71	1.50
Putrescine	5.22	8.90	6.52	1.01	3.33	1.84
Cadaverine	9.08	17.45	12.00	8.80	11.40	9.12
Histamine	16.00	12.07	6.80	8.00	3.00	1.23
Tyramine	10.90	6.72	4.41	5.60	4.80	3.45
Total BAs	44.1	50.59	32.73	24.15	25.24	17.14

Farm 1: Irrigated from El-Batts drain. Farm 2: Irrigated from El-Wadi drain

3.3. Microbiological aspects of farmed mullet fish

To assess the safety of smoked mullet fish; total bacterial count, coliform count and yeast and mold count were carried out and the data obtained are tabulated in Table (3).

3.3.1. Total bacterial count (TBC)

The obtained results showed that the smoking procedures caused the reduction of total bacterial count. TBC of raw mullet fish sample obtained from farm (1) was 4.26 Log_{10}cfu/g sample, decreased to 3.35 and 3.05 log_{10}cfu/g of cold and hot smoked fish

samples, respectively. Also, it was 3.36 log_{10}cfu/g sample decreased to 3.12 and 2.85 Log_{10}cfu/g of cold and hot smoked fish samples (farm 2), respectively. It is clearly showed that hot smoking method caused a markedly decline in the total bacterial count compared to cold smoking, this may be due to high temperature used in hot smoking. The reduction in total bacterial load of the smoked catfish products may be due to the actions of several factors. The antimicrobial effect of smoke constitutes, heating during smoking and partially dehydration in addition to the effect of sodium chloride in lowering the water activity of fish muscles and the harmful action of chloride ion of sodium chloride on microorganisms (Lueck, 1980). Similar results were reported by Abd El-Mageed (1994); he observed that the total bacterial count (TBC) of fresh silver carp fillets was 12 $\times 10^3$ cell/g decreased to 6×10^3 cell/g and 4×10^3 cell/g in the cold and hot smoked fillets, respectively. El-Lahamy et al. (2018) reported that TBC of fresh raw catfish fillets samples decreased from 4.49 to 3.07 and 3.23 log_{10}cfu/ g for hot smoked fillets and cold fillets which clearly showed that hot smoking method caused a markedly decline in the total bacterial count. Mohamed (2018) evident that total viable count (TVC) of fresh mullet fish were 3.2 and 3.45 $\times 10^4$cfu/g for samples obtained from two fish farms at fayoum governorate reduced after cold smoking to 2.35 and 2.0 $\times 10^4$cfu/g, respectively. Also, Abo-Zeid (2020) found that total bacterial count (TBC) of fresh raw catfish samples was 3.96 log_{10}cfu/g decreased to 3.68 of cold smoked control sample and to 3.22, 2.90 and 3.55 log_{10}cfu/g sample of smoked catfish fillets treated with thyme, rosemary and cumin, respectively.

3.3.2. Total coliform bacterial count (TCBC)

From Table (3), the obtained data illustrated that coliform count was 2.84 log_{10}cfu/ g for raw mullet fish from farm (1) decreased to 1.64 and 1.22 log_{10}cfu/g of cold and hot smoked fish samples, respectively. While, it was 2.00 log_{10}cfu/ g for raw mullet fish from farm (2) decreased to 1.2 and 1.00 log_{10}cfu/g of cold and hot smoked fish samples, respectively. Also, the reduction in total bacterial load of the smoked catfish products may be due to the actions of several factors. The antimicrobial effect of smoke constitutes, heating during smoking and partially dehydration in addition to the effect of sodium chloride in lowering the water activity of fish muscles and the harmful action of chloride ion of sodium chloride on microorganisms (Lueck, 1980**)**.

3.3.3. Yeast and mold counts

The present results evident that yeasts and mold took the same trend as bacteria in decreasing during fish smoking, yeasts and mold count was 1.88 Log_{10}cfu/ g for raw mullet fish from farm (1) decreased to 1.20 and 0.82 log_{10}cfu/g of cold and hot smoked fish samples, respectively. For raw mullet fish from farm (2), yeasts and mold count was 1.54 log_{10}cfu/ g for raw mullet fish from farm (2) decreased to 1.00 and 0.50 log_{10}cfu/g of cold and hot smoked fish samples, respectively. This observation may be attributed to the effect of concentration of salt and smoke during smoking process. The hot smoking was effective more than cold smoking in the reduction of vegetative molds and yeasts growth. Similar results were found by Ikeme (1986) reported that the value of yeast and mould counts of smoked mackerel fish tissue was markedly reduced after hot smoking. Also, Ibrahim (1999) found that the counts of yeast and mold reduced after cold smoking, due to the effect of smoke

compounds penetrated into fish tissue. Also, these results agreement with reported by El-Lahamy et al. (2018) and Abo-Zeid (2020). Meanwhile, Abd El-Mageed (1994) observed that the yeast and mould count did not detect in cold and hot smoked silver carp fillets immediately after smoking process. Mohamed (2018) illustrated that yeast and mold (Y&M) count not detected in all fresh and smoked catfish fillets.

Table 3: Effect of smoking process on microbiological aspects of mullet fish obtained from farms 1 and 2

Microbiological aspects (Log_{10}cfu/g)	Farm 1			Farm 2		
	Raw fish	Smoked fish		Raw fish	Smoked fish	
		Cold	Hot		Cold	Hot
TBC	4.26 ± 0.50	3.35 ± 0.11	3.05 ± 0.12	3.36 ± 0.22	3.12 ± 0.09	2.85 ± 0.21
TCBC	2.84 ± 0.08	1.64 ± 0.11	1.22 ± 0.03	2.00 ± 0.10	1.20 ± 0.19	1.00 ± 0.05
Y&M	1.88 ± 0.30	1.20 ± 0.05	0.82 ± 0.01	1.54 ± 0.31	1.00 ± 0.08	0.50 ± 0.11

Data (n=3) are calculated as mean ± (SD) Standard deviation;. Farm 1: Irrigated from El-Batts drain. Farm 2: Irrigated from El-Wadi drain. w.w.: On wet weight basis. TBC: Total bacterial count. TCBC: Total coliform bacteria. Y&M: Yeast & mould. Cfu: colony forming unit

4.CONCLUSION

The results in present study indicated that the quality and safety of raw and smoked mullet fish from farm (2) higher than of farm (1). The values of quality parameters, biogenic amines and microbiological aspects were lower than maximum permissible limits. Hot smoked samples were higher quality and safety than cold smoked samples. Cold and hot smoking process could be reduced the values of potential sources raised the acceptable level of consumer.

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